

Melting of Fe-FeO System at High Pressures

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Introduction: The nature and composition of the earth's core is a fundamental question in geochemistry. Although it is now widely accepted that the core consists of a mixture of iron and light element(s), the issue of the nature of this mixture is yet to be resolved. The two most popularly accepted light elements are S and O. The crucial input to these questions is in turn the melting behavior of Fe-FeS and Fe-FeO binaries at pressures beyond 80 GPa. A number of theoretical and experimental studies have indeed addressed this basic question¹⁻⁵. However, there has been no consensus on this complex issue. On the experimental side, the determination of the melting curve has been controversial^{4,5}. The technique employed in both these studies has not been able to unambiguously determine whether the systems are miscible or define a solid solution⁶. In an effort to make a systematic mapping of the phase diagram, we chose to combine both visual observation and x-ray diffraction measurements while the sample is held at high pressures and temperatures in the diamond anvil cell.

Methods and Materials: Five different compositions of Fe-FeO were used as starting materials. To ensure proper mixing and to obviate the problem of small sampling areas, mixtures were made with 1-5 micron sized particles. Well-mixed mixtures were loaded into diamond anvil cells with Ar and NaCl as pressure media in separate runs for each of the pressures studied. The loading was performed in glove bags flushed with flowing N₂ gas to eliminate moisture and ensure no significant changes in starting composition. At each pressure, the sample was heated using a double-sided laser heating setup with a Nd:YAG laser. In-situ diffraction patterns were obtained rapidly making use of a focused x-ray beam with a nominal beam size of 15x15 microns and a hot spot of 30x30 microns to ensure uniform heating. Temperature was measured by spectroradiometry to obtain both the peak temperature and the axial profile.

Results: The measurements on all the starting compositions were possible up to pressures of the order of 70 GPa. At higher pressures, only a few of the compositions could be successfully studied. The highest pressure achieved was 105 GPa for a starting composition of Fe_{0.25}FeO_{0.75} in NaCl medium.

Conclusions: The two main conclusions of these series of experiments have been the observation of a eutectic behavior and depression of the $\epsilon \rightarrow \gamma$ phase boundary in Fe. In a typical run, we were able to observe the melting of one of the two components depending on which side of the eutectic the starting composition laid. This temperature was well bracketed both by heating the sample to just above the eutectic point and cooling it from above the eutectic temperature. For pressures below 70 GPa, we were able to obtain good constraints on the phase diagram of the Fe-FeO system.

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